- **Teams may have the following:**
  - **One stand-alone, non-programmable, non-graphing calculator.**
  - **One hard copy 8.5" x 11" sheets of paper with information from any source. Electronic notes are fine to**
- **Partial credit will be awarded accordingly.**
- **If you are not certain as to what you should be doing, or if a question does not make sense to you, ask the eve what to do.**
- **For fill-in-the-blank questions, assume your answer to be singular unless you're given different instructions.**
- **You have 50 minutes to complete this test. Good luck!**

Exam Author: Mayur Chhitu, *University of California, Riverside*, B.S., Biochemistry 2023

2021 Rickards Invitational: Water Quality B/C- Answer Key
(https://docs.google.com/document/d/15kJiWMm0p7zVbGArldrt8FQKddqj7mB_d6I59a__NHw/edit#heading=h.qd1ji0ks00e7)

Part I: Marine & Estuary Ecology

1. (2.00 pts) Select all the appropriate compounds that are responsible for most HABs?

(Mark **ALL** correct answers)

- [ ] A) Carbon dioxide
- [x] B) Nitrates
- [ ] C) Sulphates
- [x] D) Phosphates

2. (1.00 pts) Which of the following symbiotic relationships describes the following image of these two organisms:

A) Commensalism

B) Mutualism

C) Parasitism

D) Predator-Prey

3. (1.00 pts) Which of the following is biologically unobtainable in regards to the water cycle?

A) Soil

B) Plant bodies

C) Ground water

D) Surface water

4. (2.00 pts)

A 55.3 mL water sample was found to contain 0.734 mg of sodium. What is the concentration of sodium in the sample, in **molarity**? Use the appropriate num figures in your answer. ^ = "power of" , x = "times", and M = molarity. **Spacing** will matter. **Example answer: 2.51 x 10^-5 M**

5.77 x 10^-4 M

5. (2.00 pts) What is the concentration of the sample in question 4, in parts per million (ppm)? Round if necessary.

A) 5.77 ppm

B) 4.71 ppm

C) 13.3 ppm

D) 8.75 ppm

6. (1.00 pts) Which of the following answer choices is not a nonpoint source pollution?

A) Runoff from a farming field.
B) Company workers dredging a harbor.
C) Suburban dwellers dumping battery acid.
D) Bass boats leaking motor oil.

7. (1.00 pts) What type of device is a Septic Snooper?

A) Thermometer
B) Seeepage meter
C) Mini-piezometer
D) Fluorometer

8. (1.00 pts) Which of the following answers correctly orders the soil horizon from top-down?

A) O, E, B, C, A, R
B) R, C, B, E, A, O
C) O, E, A, B, R, C
D) O, A, E, B, C, R

9. (1.00 pts) Phosphates leach more readily into surface and groundwaters than nitrates.

True False

10. (2.00 pts) Which of the following answers highlights the effects of high dissolved oxygen concentration in wastewater treatments?

(Mark **ALL** correct answers)
A) Favors filamentous organisms that won't settle in clarifiers.
B) Insufficient BOD removal.
C) Wastes energy.

D) Odors.

11. (1.00 pts)
Which of the following answers highlights the effects of a low F/M, or Food to Mass Ratio- ratio of influent BOD/ day to mass of microorganisms in a sequer reactor?

A) Microorganisms can't handle all the "food".
B) Insufficient BOD removal.
C) Favors filamentous microorganisms causing poor settling.
D) Viscous bulking causing poor settling.

12. (1.00 pts) Which of the following characteristics about K strategists is false?

A) Large size, slow growth.
B) Long life span.
C) Opportunistic species.
D) Few offspring with low mortality and care-taking of young.

13. (1.00 pts) The strongest change in salinity over a certain depth occurs in which oceanic water column?

A) Thermocline
B) Pycnocline
C) Halocline
D) Deep Layer

14. (1.00 pts) The most common wastewater treatment disinfection process is:

A) Ultraviolet light
B) Ozonation
C) Chlorination
D) Sterilization

15. (2.00 pts) Which of the following is the geometric mean of the following fecal coliform sample counts: 12, 573, 2500?

- A) 1,028
- B) 984
- C) 3,085
- D) 258 (selected)

16. (1.00 pts) What will happen to the pH of water if chlorine gas was injected into it?

- A) Increase in pH
- B) Decrease in pH (selected)
- C) Fluctuates in pH
- D) No change in pH

17. (1.00 pts) The nitrogen cycle process that converts NO_3^- to N_2 is called:

- A) Nitrification
- B) Ammonification
- C) Denitrification (selected)
- D) Assimilation

18. (1.00 pts) What does a Secchi disk measure?

- A) Total solids
- B) Fecal coliforms
- C) Turbidity (selected)
- D) Dissolved oxygen

19. (2.00 pts) Which of the following compound(s) would not be categorized as PFAS chemicals?

- A) Perfluoroocotanesulfonic acid
- B) GenX

C) Ammonium perfluorononanesulfonate

D) Perfluoro-4-(perfluoroethyl)cyclohexylsulfonate

E) Dichlorobiphenyl

20. (1.00 pts) What is the MCL for Arsenic?

A) 1 mg/L

B) 0.1 mg/L

C) 0.01 mg/L

D) 0.001 mg/L

21. (1.00 pts) Under a pH of 6, which of the following processes is inhibited?

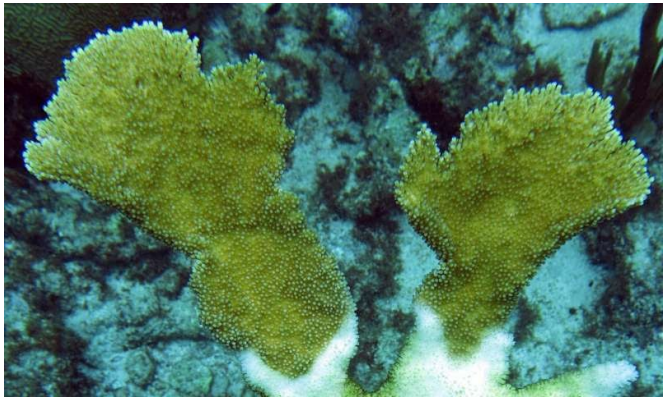
A) Nitrification

B) Dentrification

C) Ammonification

D) Assimilation

22. (1.00 pts) Which of the following diseases is captured on the following image:



A) White Plague

B) White Band

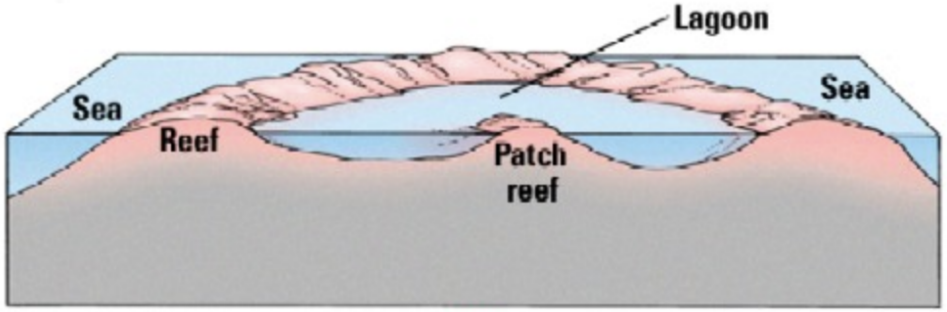
C) White Pox

D) Aspergillosis

23. (1.00 pts)
Many scientists categorize the distribution of estuary organisms to better understand an estuary community. Which category would an organism that can toler
estuary's mouth at 20% salinity:

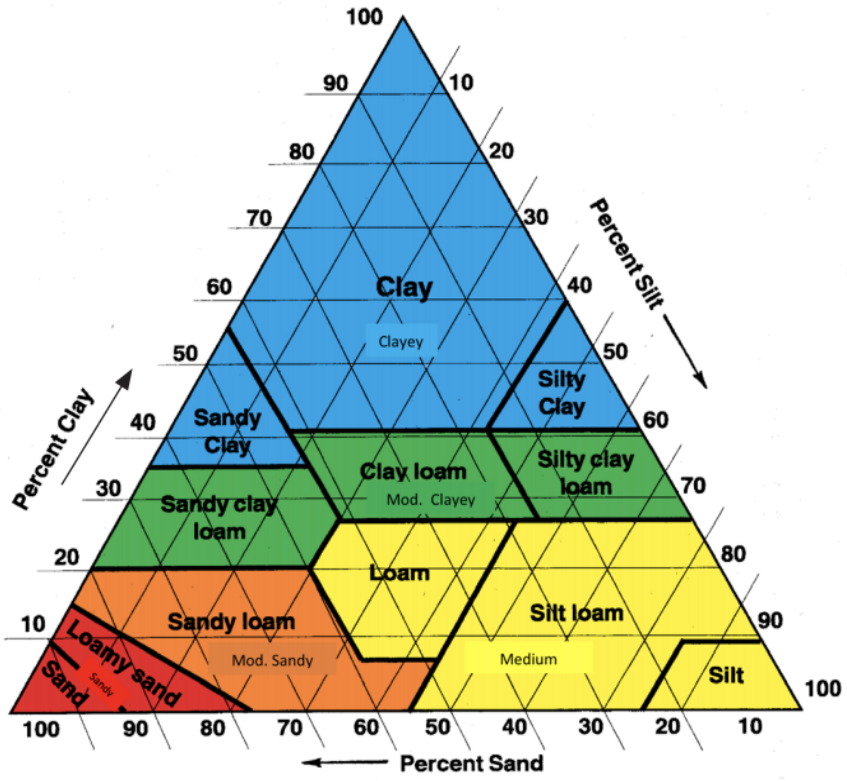
- A) Euryhaline marine organisms
- B) Estuarine organisms
- C) Oligohaline organism
- D) Stenohaline marine organisms

24. (1.00 pts) Which of the following coral reefs identifies the image below:



- A) Barrier
- B) Atoll
- C) Fringing
- D) Bar-built

Soil plays an important role in septic systems for wastewater treatment once effluent contacts the soil and microbes feed on wastewater nutrients to form micr
type plays a role in effluent rates. Use the soil textural triangle below to answer the following questions:



25. (1.00 pts) A soil composition of 18% sand, 37% silt, and 45% clay will have which of the following texture:

- A) Clay
- B) Clay Loam
- C) Silty Clay
- D) Silty Clay Loam

26. (1.00 pts) Determine the soil texture based on thee following properties:

- Aeration: Medium
- Water-holding capacity: Poor
- Water-infiltration capacity: Good
- Nutrient-holding capacity: Poor
- Workability: Good

- A) Clay

B) Silt

C) Sand

D) Loam

There are many other sources of chloride ions such as runoff from salted roads or the mixing of seawater with freshwater. An experiment was conducted to m
of an estuary, specifically it's chloride concentration from $CaCl_2$, using a

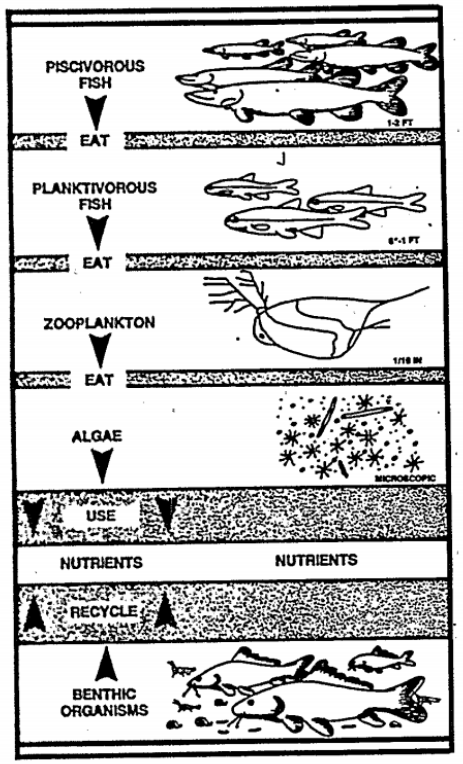
- Chloride ISE. Salinity (ppt) = 0.0018066 * Cl^- (mg/L). The data that scientists acquired:

27. (2.00 pts)
Determine the salinity of water in terms of chloride concentration (ppt). **Hint: 1 mL/L = 1000 mg/kg. Two sig figs. Round** if necessary. **Example answer: 0**

- Chloride ion solution (mg/kg): 18740 mg/kg

0.034 ppt

28. (1.00 pts) The food chain concept involves the flow of energy and the recycling of nutrients. Based on the following image, the planktivorous fish can b



A) Detritivores

B) Quaternary Consumers

C) Secondary Consumers

D) Producers

E) Tertiary Consumers

Imagine an aquaculture site near a farmer's field (now eroding) that was infested with DDT. Wind blows some of the pesticide into the lake, threatening the a with DDT. Each zooplankton receives 1 unit of DDT. Answer the following questions pertaining to this biomagnification.

29. (2.00 pts) If each planktivorous fish eats 150 zooplankton in a year, how many DDT units will the fish accumulate? **Example answer: 790 units of DD**

150 units of DDT

30. (2.00 pts) If each piscivorous fish eats 70 planktivorous fish in a year, how many DDT units will the piscivorous fish accumulate? **Example answer: 7**

Use a comma in your answer if needed.

10,500 units of DDT

31. (1.00 pts) Wastewater is 99.9% water while the 0.1% remaining contains organic matter, inorganic compounds, and microorganisms.

True False

32. (1.00 pts)

Finish the following equation by balancing the coefficient: $NH_4 + \_\_ O_2 \rightarrow NO_2^{2-} + 2H^+ + H_2O$ | **If applicable, your answer should not be in decimal form b number or in fraction form.**

3/2

33. (2.00 pts) Which of the following compounds is the most expensive chlorine-releasing compound used for chlorination processes?

A) NaOCl

B) Ca(OCl)2

C) Cl2

D) KOCl

34. (1.00 pts) Which of the following correctly exemplifies a Type I, II, and III organism in that order?

A) Rhino, Trees, Wrasse
B) Hydra, Human, Oyster
C) Humpback Whale, Warbler, Dandelion
D) Tree, Squirrel, Human

35. (1.00 pts) A sample of water has a pH of 1.0. A pH from 1.0 to 3.0 would change the acidity by a factor of:

A) 3
B) 1/3
C) 1,000
D) 0.01
E) 0.001

36. (2.00 pts) **Describe** why the term garbage "patch" is misleading when understanding its environmental impact?

Expected Answer: +2: "Patch" is a misleading nickname, causing many to believe that these are islands of trash. Instead, the debris is spread across the surface o
from the surface all the way to the ocean floor. The debris ranges in size, from large abandoned fishing nets to tiny microplastics, which are plastic pieces smaller th
This makes it possible to sail through some areas of the Great Pacific Garbage Patch and see very little to no debris.

37. (3.00 pts) **What** does GPGP stand for? Besides location, **why** is it unique compared to other gyres?

Expected Answer: +1: Identification- The Great Pacific Garbage Patch +2: Reasoning- Unique because it is the largest ocean gyre.

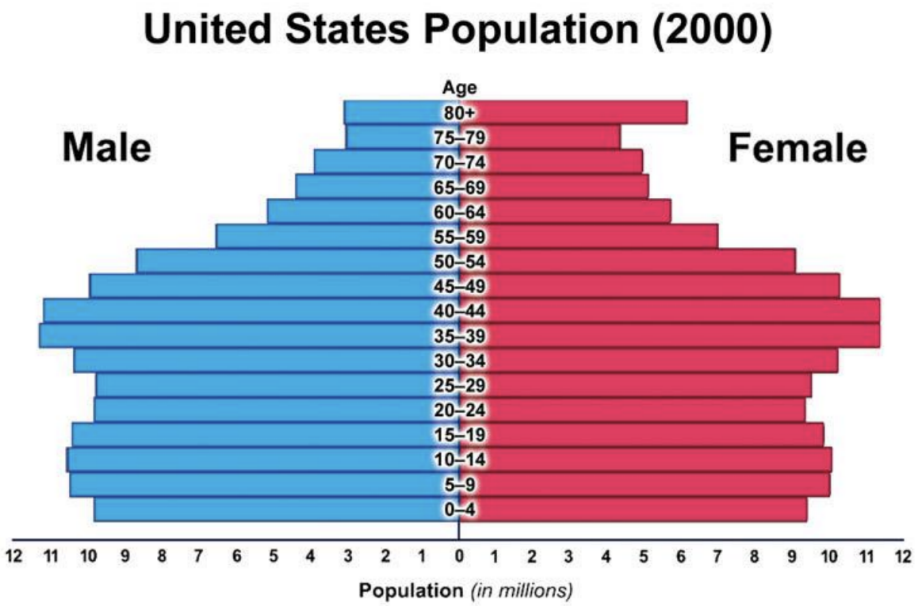
38. (1.00 pts) An increase in surface seawater CO_2 levels results in a:

- A) Increase in Ω.
- B) Decrease in Ω.
- C) Ω equals to 1.
- D) No change to Ω.

39. (2.00 pts) What can you conclude if in the Lotka-Volterra equations that x or y equal to zero?

Expected Answer: That there can be no predation.

Refer to the below population age structure when answering the following questions.



40. (3.00 pts) What type of population pyramid is this? In which categories are the populations the highest?

Expected Answer:

41. (2.00 pts) In which age category is the population of males and females the most different? Why do you think that is?

Expected Answer: +1 for identification- post-reproductive (40+ years old) +1 for reasoning (e.g. men die earlier; job, health, or due to being more physical)

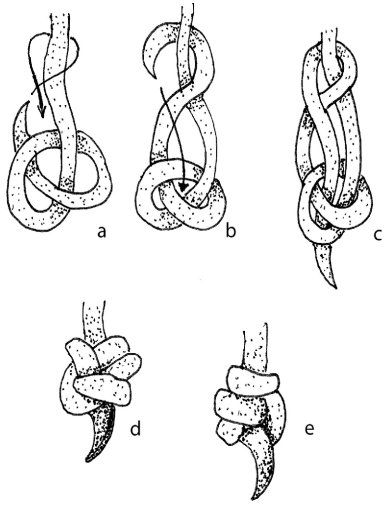
42. (1.00 pts) How many millions of males and females are shown in your age category?

Expected Answer: +1 for valid answer- 20-22 million

Part II: Coral Reef Fauna & Fauna Identification

Figure A

Figure B



43. (2.00 pts) Identify the above image (**Figure A**) (Don't worry, it doesn't bite, or does it…). **Common name only.**

Moray | eel

44. (2.00 pts) Which of the following correlates to this organism's embryonic development?

- A) Ovoviviparous
- B) Viviparous
- C) Oviparous
- D) Matritrophous

45. (3.00 pts) **Describe** the process behind the organism's feeding behavior in **Figure B**. **Why** does **Figure B** do this?

Expected Answer: +2: Description- They have a very distinct and feeding pattern known as rotational feeding where they exhibit a type of feeding behavior called Rotational feeding essentially is where an organism utilizes its longitudinal axis to spin, thereby enabling it to tear apart large prey. 'Knotting' can be denoted as a se elaborate movements which include: the positioning of the tail in a backward movement, under the middle of its body, followed by the creation of a second loop by p back up and into the first loop. The two loops are then tightened, after which the eel draws its head backward through the loops, thus rendering the prey decapitated swallowed. +1: Reasoning- To tear down its prey (e.g. octopi)- youtube.com/watch?v=c2UKg92Hb5M

Figure C

Figure D

46. (2.00 pts) Identify the above image (**Figure C**). **Common name only.**

Sea | cucumber

47. (3.00 pts)

- **What** is the scientific name for the creatures on another kind of **Figure C**?
- **Describe** the symbiotic relationship in the **Figure D**.

Expected Answer: +1: Identification- Periclimenes imperator +2: Relationship- Commensalism; The shrimp gets protection from the sea cucumber from predators cucumber does not get any benefits.- https://www.youtube.com/watch?v=RHZGBXBwzJU

48. (2.00 pts) How does this organism (**Figure C**) play a role in a pearl fish's life cycle?

Expected Answer: +2: Relationship- A variety of fish, most commonly pearl fish, have evolved a commensalistic symbiotic relationship with sea cucumbers in whic live in sea cucumber's cloaca using it for protection from predation, a source of food (the nutrients passing in and out of the anus from the water), and to develop int of life.

49. (2.00 pts) Which of the following organisms are predators?

(Mark **ALL** correct answers)

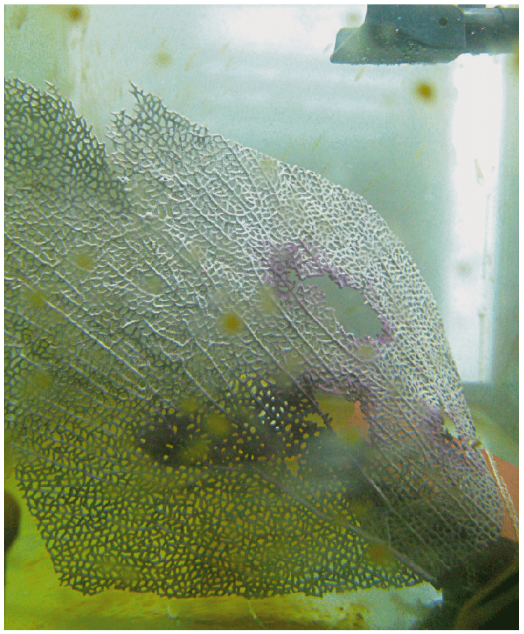
- [ ] A) Flamingo Snail
- [x] B) Humans
- [x] C) Tuns
- [ ] D) Polynoids

50. (4.00 pts)

- The toxic chemical that **Figure C** releases as a defense mechanism is similar to what group of compounds?
- What are those white expelled contents called? Describe the purpose for them.

Expected Answer: +4 points: +1: Identification- Saponins (soap-like) (e.g. holothurin) +1: Identification- Cuvierian tubules. +2: Description- Fine sticky tube enlarge respiratory tree that float freely in the coelom to entangle potential predators. When startled, these cucumbers may expel some of them through a tear in the wall of autonomic process known as evisceration.

Figure E



51. (2.00 pts) Identify the above organism (**Figure F**). **Common name only.**

sea | fan

52. (2.00 pts) What disease does this organism have?

Aspergillosis

53. (6.00 pts)

- What structure acts as a holdfast organ as the base expands?
- **Describe** the relationship between **Figure E** and zooxanthellae?
- As an adult, how does **Figure E** maximize food exposure?

Expected Answer: +6 points: +2: Identification- Pedal disk +2: Relationship- Most reef-building corals have a unique partnership with tiny algae called zooxanthella within the coral polyps, using sunlight to make sugar for energy. This energy is transferred to the polyp, providing much needed nourishment. In turn, coral polyps p with carbon dioxide and a protective home. +2: Description- Adult sea fans are assisted in feeding by growing perpendicular to water currents, maximizing exposure would bring food using its tentacles.

Figure F

54. (5.00 pts)

- **Identify** the above organism.
- **Identify** this organism's active prey.
- **Describe** the gripping, killing, and consumption.
- **Where** in the prey does the organism began consumption?

Expected Answer: +5 points: +1: Identification- Triton's Trumpet +1: Recall- Crown-of-Thorns Starfish +2: Description- The triton grips its prey with its muscular foo toothy radula (a serrated, scraping organ found in gastropods) to saw through the starfish's armoured skin. +1: Description- Once it has penetrated, a paralyzing sa prey and the snail feeds at leisure, often beginning with the softest parts such as the gonads and gut.

55. (7.00 pts)

- **Identify** and **describe** the structure that helps **Figure F** prevent dehydration?
- **What** is the structure made out of?
- **Describe** the other purpose that it serves?
- **Name** the alternative structure that many pulmonate species create?

Expected Answer: +7 points: +1: Identification- Operculum +2: Description- A "trapdoor" used to close the shell's aperture using columellar muscles to minimize de Recall- It has a corneous shell, not calcerous, so it's made out of chonchilon or conchins (complex proteins). Binded by aragonite through environmental means to g +2: Description- The operculum serves as protection against predators when the snail body is retracted. Sand-digging as a means of locomotion is a feature only pe conchs with claw-shaped operculum (e.g. family Strombidae- true conchs). +1: Recall- Epiphragm

Figure G

56. (2.00 pts) Identify the above organism (**Figure G**) by its **scientific family name**.

Lutjanidae

Figure H

Figure I

57. (4.00 pts)

- **Identify** the above organism (**Figure H**).
- **What** is the fisherman (**Figure I**) spraying?
- **What** type of fishing is this called?
- **Identify** one of this organism's prey from the SciOly Water Quality rules.

Expected Answer: +4 points: +1: Identify- Humphead wrasse +1: Recall- Cyanide +1: Recall- Cyanide fishing +1: Identify- Crown-of-thorns starfish, Sea cucumber

Part III: Water Monitoring

58. (3.00 pts)
A baby lives in a rural region where their only source of water is from an unregulated well. The baby drinks the water and presents to the village clinic, lethar
What is the name of the underlying medical condition called? **Three-word answer.**

Baby | blue | syndrome

59. (3.00 pts) What does WAS stand for?

Waste | activated | sludge

60. (2.00 pts) What is a temporary solution for acidification in digester operations?

Expected Answer: +2 points: +2: Ca(OH)2. CaO alone is not a valid answer (must be CaO + H2O). Calcium sulfite alone is not a valid answer (must be calcium su
Or changing pipes. Ammonium nitrate. +1: Incomplete treatment solution

61. (2.00 pts) What is the name of the device below?

Rotameter

62. (4.00 pts)

A chlorine feed system uses this device (from #10). It is set at 60 lb/day. If the chlorine gas is applied for 30 minutes to a 40-foot diameter tank containing wa level, what is the **chlorine dosage** in mg/L? **1 sig fig**. **Partial credit is possible.**

- Dose, mg/L = (Pounds of Chemical, lbs)/(8.34 lbs/gal) (gallons, in millions)
- 1 day = 1,440 minutes
- 1 cu ft. = 7.48 gallons
- $V = (\pi/4 * D^2 * H)$; D = Diameter; H = Height

Expected Answer: +4 points: Indicated as +1 accordingly Image 1

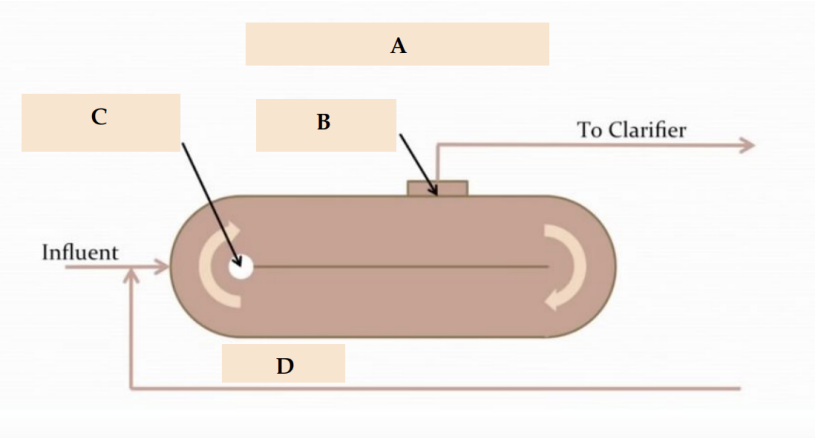
63. (2.00 pts) Calculate the **chlorine demand** if the measured chlorine residual test after thirty minutes of contact time is 0.5 mg/L. **Partial credit is possib**

Expected Answer: +2 points: Indicated as +1 accordingly Image 1

64. (4.00 pts)

The following questions will ask you to identify the following type of treatment plant, its parts, and relevant water quality questions:

- Identify the type of water treatment plant pictured below (Label A)?



- Use that image to correctly **identify** B, C, and D.

Expected Answer: +4 points: +1: Identification- Oxidation ditch +1: Identification- Effluent weir +1: Identification- Mechanical surface aerator +1: Identification- Retu Sludge (RAS)

A water sample is taken from a stream that passes through soils containing gypsum ($CaSO_4$), some of which dissolves. The stream already carries some Ca^{2+} a dissolved from other mineral sources. Laboratory analysis of the water shows SO_4^{2-}= 347 mg/L; Ca^{2+}= 562 mg/L. The solubility product is 2.4 * 10^{-8}.

65. (2.00 pts) Calculate the concentration of Ca^{2+} in **2 sig figs** and **"M" units**. **Example answer: 2.6 x 10^-9 M. No "." after M. Be careful with spacing**

1.4 x 10^-2 M

66. (2.00 pts) Calculate the concentration of SO_4^{2-} in **2 sig figs** and **"M" units**. **Example answer: 2.6 x 10^-9 M. No "." after M. Be careful with spacin**

3.6 x 10^-3 M

67. (2.00 pts) Will gypsum precipitate develop in the stream? **True** for **Yes**, **False** for **No**.

◉ True ○ False

A 50.0 mL sample of wastewater from a conventional household septic tank was placed into a 300 mL BOD beaker. The rest of the bottle is filled with aerate
The initial dissolved oxygen was 7.60 mg/L and after 5 days the dissolved oxygen was 3.80 mg/L.

68. (2.00 pts) **What** is the BOD_5 of the water sample in mg/L? **Round** your answer to the nearest whole number.

23 mg/L

69. (2.00 pts)

- **What** is the typical BOD_5 concentration found in a conventional household septic tank?
- **Determine** whether or not the calculated sample concentration is more or less than found in a typical household septic tank.

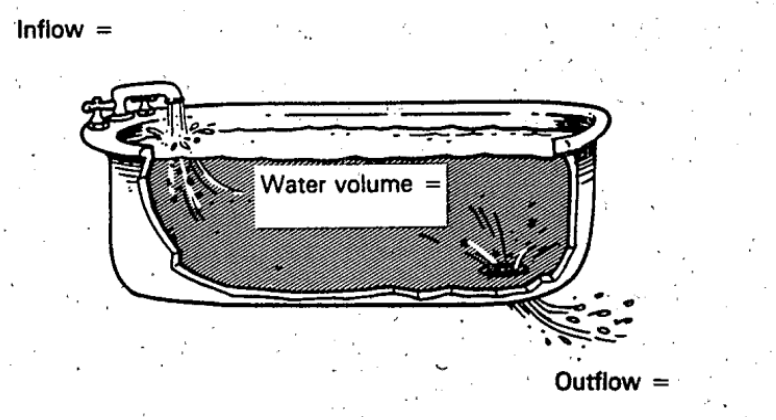
Expected Answer: +2 points: +1: 50-150 mg/L +1: Less than typical (which is good).

Part IV: Free Response

70. (8.00 pts)
Describe the physical and chemical process behind the primary and secondary wastewater treatment system. **Give** at least four physical/chemical component
treatment.

Expected Answer: +8 points: +4 for description (primary & secondary) +1 (each) for component +2: Description- After raw sewage input, grit removal, and mixing c
main step that occurs is a typical wastewater treatment facility is the primary clarifier. In it, suspended solids are stuck together by added flocculants such as alum a
agents over a detention period, separating it from the liquid influent via gravity. +2: Description- After that, a biological treatment process occurs where organic mate
aeration tank. Indigenous, water-born microorganisms in a managed habitat help remove dissolved and suspended biological matter. Use of secondary clarifier is to
biological floc.

Hydraulic residence time (HRT) is an important factor to consider in restoration programs to prevent odors, fishkills, increased phosphorus and ammonia con
other undesirable effects. **Volume = 60 gallons | Inflow = Outflow = 20 gallons/minute . The drain is fully opened.** Use the following image to answer the



71. (2.00 pts)
Calculate the HRT of this bathtub if the drain was only **half-opened** Include the correct units. **1 sig fig**. **Example answer: 3 minutes. Include "minutes" no answer.**

6 minutes

72. (6.00 pts) Pretend that the bathtub is a lake basin. **Describe** what would happen to an aquatic ecosystem's algal cell count, nutrient supply, and BOD, if

- HRT was short (10 days or less)
- HRT was long (100 days to several years)

Expected Answer: +6 points: (10 days or less): +1: Algal cell count- Washed out faster than they can grow and accumulate. (10 days or less): +1: Nutrient supply- algal cell count decreases. (10 days or less): +1: BOD- Is not high. (100 days to several years): +3 Opposite of ^^^

A Minnesota community is considering a potential design of a wastewater treatment plant made by a famous engineer. The community raw sewage has an av BOD_5 and 280 mg/L of suspended solids. Assume that the primary sedimentation process removes 50% of the suspended solids (SS) and 30% of the raw sew

- 1 gal = 3.785 L
- 1 lb = 453,592 mg = 0.4536 kg.

73. (4.00 pts) **Determine** the SS and BOD_5 concentrations in the primary sedimentation effluent flow **(mg/L)**.

Expected Answer: +4 points: Indicated as +2 accordingly +2: 140 mg/L | Image 2 +2: 154 mg/L | Image 2

74. (1.00 pts) Is the BOD_5 concentration within range of the U.S. municipal influent? **True** means **Yes**, **False** means **No**

- (●) True
- ( ) False

75. (2.00 pts)
Determine the mass of primary sludge produced per day as dry solids **(lb/day)**. **Use the comma if necessary in your answer. Example answer: 2,975 lb/da between "lb" and "day". 4 sig figs.**

1,168 lb/day

76. (3.00 pts)
Use the dry mass flow answer to find the wet sludge flow **(gallons/day). Hint:** First calculate SS_{wet}. **Partial credit is possible! Round** your answer to the ne number.

- Sludge concentration of 6% solids
- Specific gravity = 1.03.

Expected Answer: +3 points: Indicated as +1 and +2 accordingly First: +1 points: 19,467 lb/day = SSwet | Image 2 Second: +2 points: 2,265 gal/day = Qsludge | Ir

Biomanipulation was first suggested by Shapiro et al. (1975), where they believed that manipulating the ecosystem can greatly improve lake quality without t chemicals and machines. For example, in some lakes, the amount of algae is controlled by grazing zooplankton rather than the quantity of nutrients.

77. (4.00 pts)

- **Describe** what may happen to higher trophic level organisms if grazed zooplankton continued to proliferate.
- **Identify** two causes of zooplankton mortality.

Expected Answer: +2: Description- That higher-level population or predator population will increase because there is more food availability. +1: Identification 1- Pr Physical stress

- **Congratulations, you have finished the water quality examination.**
- **Feel free to fill out this test feedback survey: tinyurl.com/RateMySciolyTests.**
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